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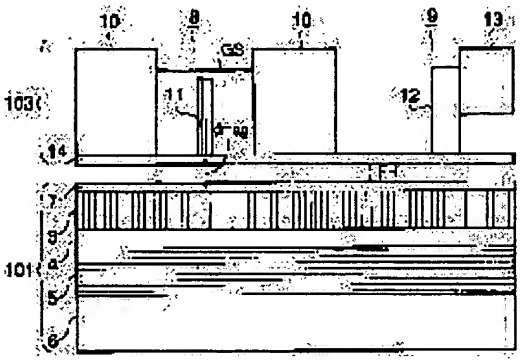
(54) MAGNETIC DISK DEVICE OF PERPENDICULAR MAGNETIC RECORDING SYSTEM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide the disk drive of a perpendicular magnetic recording system, wherein the disk recording medium of a perpendicular double-layer structure, and a GMR element as a reading head are combined.

SOLUTION: The disk drive of a perpendicular magnetic recording system is provided with the disk 101 of a perpendicular double-layer structure, and a magnetic head 103 including a reading head 8 as a GMR element 11. The GMR element 11 has a linear response dynamic range characteristic larger than the average value of a reproducing magnetic field from the disk 101, and a characteristic capable of evading or suppressing a saturation phenomenon even when there is an effect of a strong reproducing magnetic field.



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CLAIMS

[Claim(s)]
[Claim 1] It is the magnetic disk unit characterized by being the magnetic disk unit of the vertical magnetic recording equipped with the magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the disk record medium and the aforementioned disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy], and the aforementioned read head element having a larger alignment response dynamic range property than the average of the reproduction magnetic field from the aforementioned disk record medium.
[Claim 2] The disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy The magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the aforementioned disk record medium] the magnetic disk unit equipped with the above -- it is -- the aforementioned read head element -- positive/negative -- it is characterized by having larger saturation magnetic influence than the average magnetic field from the aforementioned disk record medium uniformly magnetized by one of polarity
[Claim 3] The disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy The magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the aforementioned disk record medium] the magnetic disk unit equipped with the above -- it is -- the aforementioned read head element -- positive/negative -- it is characterized by having the alignment response magnetic influence which shows larger maximum than the average magnetic field from the aforementioned disk record medium uniformly magnetized by one of polarity
[Claim 4] The disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy The magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the aforementioned disk record medium] the magnetic disk unit equipped with the above -- it is -- the aforementioned read head element -- positive/negative -- it is characterized by having a larger artificial antiferromagnetism joint magnetic field than the maximum magnetic field from the aforementioned disk record medium uniformly magnetized by one of polarity
[Claim 5] The disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy The magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the aforementioned disk record medium] It is the magnetic disk unit equipped with the above, and when the aforementioned read head element sets an artificial antiferromagnetism joint magnetic field to Hex and sets [shield gap length] residual magnetization of dmag and the aforementioned record magnetic layer to Mr for the distance from Gs and the aforementioned read head element to the front face of the aforementioned record magnetic layer, it is characterized by having the property of satisfying relational expression "Hex>8 Mr*arctan [Gs/(2dmag)]."
[Claim 6] The disk record medium of the perpendicular two-layer structure of it being used as a data-logging medium of vertical magnetic recording, and having the record magnetic layer and soft-magnetism layer of a perpendicular anisotropy The magnetic head which has a read head element magnetoresistance-effect type [for reproducing data from the aforementioned disk record medium] It is the magnetic disk unit equipped with the above, and is characterized by for the aforementioned disk record medium having a bias magnetic field impression layer for fixing the magnetization direction of the aforementioned soft-magnetism layer, and the aforementioned read head element having the property that the direction of the vertical bias which determines the operating point becomes in the same direction as the

magnetic field received from the aforementioned bias magnetic field impression layer.

[Claim 7] An aforementioned magnetoresistance-effect type read head element is the magnetic disk unit of a publication either among a claim 1 to the claims 6 characterized by consisting of huge magnetoresistance-effect type (GMR) elements.

[Claim 8] The aforementioned read head element is the magnetic disk unit of a publication either among a claim 1 to the claims 6 which are the spin bulb type GMR element which has a hard magnetic film for vertical bias, and are characterized by having the property set or more to three in the ratio (Mrt/Mst) of the product Mst of the magnetization and thickness of a free layer, and the product Mrt of the residual magnetization of the hard magnetic film concerned, and thickness.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] When the disk record medium of perpendicular two-layer structure is generally used especially for this invention about the magnetic disk unit of a vertical recording method, it relates to the magnetic disk unit which has improved the reproducing characteristics of the GMR type read head to the disclosure magnetic field from the disk record medium concerned.
[0002]
[Description of the Prior Art] In recent years, in the field of the magnetic disk unit which makes a hard disk drive representation, vertical magnetic recording attracts attention as technology for exceeding the limitation of the recording density in the magnetic-recording (longitudinal magnetic recording) method within a field. In this vertical magnetic recording, utilization of the disk drive which uses the disk record medium (a disk is only called below) of two-layer structure as a record medium is promoted.
[0003] The disk of two-layer structure has a soft-magnetism layer (called a backing soft-magnetism layer) between the record magnetic layer which shows a vertical magnetic anisotropy, and a record magnetic layer and a substrate concerned. A soft-magnetism layer passes a part of magnetic flux generated from one magnetic pole of a head at the time of data-logging operation to the magnetic pole of another side, and has a function which supports record operation of a head so to speak. Moreover, by the disk of two-layer structure, in order for the magnetization and reproduction element of a soft-magnetism layer which are the lower part of a record magnetic layer to join together magnetically and to operate at the time of reproduction operation of a head, a larger reproduction magnetic field than the case where there is no soft-magnetism layer theoretically occurs.
[0004] Utilization of the disk drive of the vertical magnetic recording applied combining such a two-layer structure disk of vertical magnetic recording and the huge magnetoresistance-effect type read head element (it is called a GMR element below) currently used by the drive of the magnetic-recording method within a field of high recording density is attained (see JP,2000-156317,A). A GMR element is a read head element which has a high reproduction sensitivity property. In the usual disk drive, the magnetic head by which the read head element concerned and the inductive mold write head element were mounted in the slider is used as a lead/write head.
[0005]
[Problem(s) to be Solved by the Invention] The conventional GMR element is developed so that a record magnetic layer may suit the disk of the thin magnetic-recording method within a field relatively. By this conventional GMR element, when reproducing the record signal perpendicularly recorded from the two-layer structure disk of a perpendicular method magnetically to the disk side, the saturation phenomenon of a GMR element occurs, and there is a problem that distortion arises in a regenerative signal. This is presumed to generate, since the operating point of a GMR element shifts and the part dynamic lens becomes narrow by the uniform magnetic field from the field magnetized uniformly other than record magnetization transition of a record magnetic layer.
[0006] By the magnetic-recording method within a field, since the magnetic field which joins a GMR element from the field magnetized uniformly was zero mostly, such a problem had not been generated. That is, this problem is a characteristic problem at the time of combining the disk and GMR element which have a vertical magnetic anisotropy. Furthermore, as mentioned above, since a larger reproduction magnetic field than the case where there is no soft-magnetism layer relating with the magnetization state of the soft-magnetism layer which is the lower part of a record magnetic layer at the time of reproduction operation of a head occurs by the disk of two-layer structure, the margin to the saturation of a GMR element is small. Furthermore, the uniform magnetic field (disclosure magnetic field) by magnetization of the adjoining truck recorded on ** on the other hand is added on a disk, and there is also a problem that it causes the saturation of a GMR element.

[0007] Then, in the disk drive of the vertical magnetic recording which combined the GMR element with the disk record medium of perpendicular two-layer structure as a read head, the purpose of this invention avoids or suppresses the saturation of the GMR element by the disclosure magnetic field from the disk record medium concerned, and is to offer the magnetic disk unit which can improve the quality of a regenerative signal as a result.
[0008]
[Means for Solving the Problem] this invention relates to the disk drive which uses the read head which consists of the disk record medium and magnetoresistance-effect type element (preferably GMR element) of the perpendicular two-layer structure of having a soft-magnetism layer as the record magnetic layer which shows a vertical magnetic anisotropy, and a lower layer of the record magnetic layer concerned in the disk drive of vertical magnetic recording. Especially the feature of this invention is in the composition which can avoid or suppress the regenerative-signal distortion by the saturation phenomenon of a GMR element, and it.
[0009] Specifically, this invention is the magnetic disk unit of the vertical magnetic recording equipped with the disk record medium of perpendicular two-layer structure, and the magnetic head which has a magnetoresistance-effect type read head element, and a read head element is the composition of having a larger alignment response dynamic range property than the average of the reproduction magnetic field from a disk record medium.
[0010] By such composition, relatively, even when the reproduction magnetic field from a disk record medium applies read head elements, such as a GMR element of high sensitivity, to the drive of strong vertical magnetic recording, it becomes possible [avoiding the saturation phenomenon by the disclosure magnetic field of the read head element concerned]. Therefore, since it is possible to secure a quality regenerative signal from a read head element, it becomes possible to realize the disk drive which combined vertical magnetic recording effective in a raise in recording density, and read head elements, such as a GMR element.
[0011] In short, the 1st viewpoint of this invention is a disk drive which uses the read head element set up so that it might become larger than the average of the reproduction magnetic field which receives the alignment response dynamic range of a response characteristic from a disk in the drive which combined read head elements, such as a GMR element, and the disk of perpendicular two-layer structure. In this case, the average of a reproduction magnetic field is the average of the magnetic field of the regenerative signal from the truck just under the reproducing head, and the reproduction magnetic field (disclosure magnetic field) from a circumference truck.
[0012] the saturation magnetic field Hs of the GMR element used as a read head element as the 2nd viewpoint of this invention -- positive/negative -- it is the disk drive which uses the read head element set up more greatly than the average magnetic field Hmu which joins the GMR element concerned from the disk uniformly magnetized by one of polarity
[0013] as the 3rd viewpoint of this invention -- the maximum Hopmax of the alignment response magnetic field of the GMR element concerned -- positive/negative -- it is the disk drive which uses the read head element set up more greatly than the average magnetic field Hmu which joins the GMR element concerned from the disk uniformly magnetized by one of polarity
[0014] in order to prevent the local flux reversal of the GMR element concerned as the 4th viewpoint of this invention -- the artificial antiferromagnetism joint magnetic field Hex of the GMR element concerned -- positive/negative -- it is the disk drive which uses the read head element set up more greatly than the maximum magnetic field Hmax which joins the GMR element concerned from the disk uniformly magnetized by one of polarity
[0015] When residual magnetization of dmag and the record magnetic layer concerned is set to Mr for the distance from the edge of the GMR element which the artificial antiferromagnetism joint magnetic field of the GMR element concerned has been arranged to Hex, and has been arranged in shield gap length at Gs and ABS (air bearing surface) of a slider to the front face of a record magnetic layer as the 5th viewpoint of this invention, it is the disk drive which uses the read head element which has the property of satisfying relational expression "Hex>8 Mr*arctan [Gs/(2dmag)
[0016] It is the disk drive which uses the disk which has a bias magnetic field impression layer for fixing the magnetization direction of a soft-magnetism layer as the 6th viewpoint of this invention, and uses the read head element which has the property that the direction of the vertical bias which determines the operating point becomes in the same direction as the magnetic field received from the aforementioned bias magnetic field impression layer.
[0017]
[Embodiments of the Invention] With reference to a drawing, the gestalt of operation of this invention is explained below.
[0018] (Composition of a disk drive) Drawing 1 shows the important section of the disk drive of the vertical magnetic recording about this operation gestalt. This disk drive is the composition that the disk 101, the spindle motor (SPM) 102, and the drive mechanism that consists of an actuator were included in the interior of the case (up covering is omitted) 107 which is a drive main part.

[0019] An actuator consists of an arm 104 containing the suspension which carries the head 103, and a voice coil motor (VCM) 105 made to move the arm 104 concerned to radial [on a disk 101]. An actuator moves a head 103 to radial [on a disk 101] at the time of read/write operation of data. Moreover, an actuator performs unload operation which evacuates a head 103 from on a disk 101 to the lamp member (not shown) arranged on the outside of a disk 101 at the time of a halt of read/write operation.
[0020] The circuit board 106 which mounts the preamplifier circuit etc. is arranged at the case 107. It has connected with a head 103 through FPC (flexible printed cable), and a preamplifier circuit transmits a read/write signal.
[0021] A head 103 is the magnetic head by which the read head element which consists of a GMR element mentioned later, and the inductive mold write head element were mounted in the slider. A disk 101 is the record medium of the perpendicular two-layer structure of having the record magnetic layer which has a vertical magnetic anisotropy, and the soft-magnetism layer (backing soft-magnetism layer) which intervenes between record magnetic layers and disk substrates concerned, as mentioned later.
[0022] (Structure of a head and a disk) With reference to drawing 1 , the structure of the head 103 about this operation gestalt and a disk 101 is explained below.
[0023] A head 103 consists of a read head 8 which consists of a huge magnetoresistance-effect type element (GMR element) formed on the substrate (AlO-TiC substrate) which is not illustrated, and inductive mold write head 9, as shown in drawing 1 . A read head 8 is the structure where the GMR element 11 has been arranged between the magnetic shielding 10 of a couple. The GMR element 11 is for example, an artificial switched connection type spin bulb GMR element, and has the film composition of PtMn/CoFe/Ru/NiFe/CoFe/Cu/CoFe/NiFe/Ta. The shield interval Gs, i.e., shield gap length, is 100nm. Height H of the perpendicular direction of the GMR element 11 is 300nm.
[0024] Write head 9 has the perpendicular single magnetic pole type record magnetic pole 12 which counters a disk 101. Furthermore, write head 9 has the yoke 13 which was magnetically connected behind the record magnetic pole 12 concerned, and has been arranged behind. It lets this yoke 13 pass, is excited with a record coil (not shown), and write head 9 generates the record magnetic field of a strong perpendicular direction to a disk 101.
[0025] Lead / write head 8 and 9 is mounted on the slider whose head 103 is a head main part. A slider has ABS (air bearing surface) for rising to surface on a disk 101. The protective coat 14 for surface protections is formed in this ABS by the thickness which is 3nm. This protective coat 14 consists of DLC protective coats which formed membranes for example, by the cathodic arc process.
[0026] The pattern for generating the positive pressure by the airstream accompanying rotation of a disk 101 is formed in ABS of the slider concerned. A slider surfaces on a disk 101 with the positive pressure concerned, for example, in the case of rotational frequency 4200rpm of a disk 101, the flying height FH in the inside periphery position (it considers as the radius of 23mm) of a disk 101 is set to about 15nm. As shown in drawing 1 from this relation, the distance dmag with the disk side front face of the front face of the record magnetic layer 3 of a disk 101 to the GMR element 11, i.e., a magnetic spacing, is the sum total (for example, 21nm) of the thickness (for example, 3nm) of the flying height FH (for example, 15nm) and a protective coat 14, and the thickness (for example, 3nm) of the protective coat 7 of a disk 101.
[0027] On the other hand, as for the disk 101, the laminating of the soft-magnetism layer (backing layer) 5, the crystal control layer 4, and the record magnetic layer 3 is carried out on the substrate 6 with an aluminosilicate system glass or a glass-ceramics quality of the material of 64mm (about 2.5 inches), for example, diameter. The soft-magnetism layer 5 is formed for example, by the sputtering forming method. The record magnetic layer 3 is formed through the crystal control layer 4 on the soft-magnetism layer 5, and is a record layer which has a good perpendicular magnetic anisotropy. The record magnetic layer 3 is a magnetic film which has the high perpendicular magnetic anisotropy to which C shaft of the HCP crystal structure which consists of Co, Cr, Pt, Ta, Co, Pt, Cr, O, etc. carries out orientation perpendicularly to a film surface, and originates in it. In the example using the CoPtCrO film, Pt concentration 20at%, it is Cr concentration 12at% and has the fine structure which oxygen segregated in a grain boundary field.
[0028] the disk of the magnetic-recording method within a field of the former [disk / of the vertical magnetic recording of this operation gestalt / 101] -- comparing -- record high at thick thickness -- since resolution can be attained and the part magnetic-particle volume increases it, it has the feature of excelling in heat fluctuation resistance With this operation gestalt, the thickness of the record magnetic layer 3 of the perpendicular anisotropy which consists of CoPtCrO is set as 25nm. As for the crystal control layer 4, Thickness t is set as about 5nm for example, with Ru quality of the material. The soft-magnetism layer 5 consists of a laminating [CoFeTaC/C] n, and the thickness of the layer 5 whole of a several n laminating is 90nm in 10. Moreover, the protective coat 7 which consists of diamond-like car methamphetamine (DLC) formed by the cathodic arc process is formed in the upper part of the record magnetic layer 3. The thickness of a protective coat 7 is about 3nm. Here, the saturation magnetization Ms of the record magnetic layer 3 is 250 emu(s)/cc (3.95T). Moreover, the residual magnetization Mr of the record magnetic layer 3 is 245 emu(s)/cc (3.87T). That is, a remanence ratio (Mr/Ms) is 0.98.

[0029] (Property of a GMR element) Drawing 2 is the property view showing the magnetic field response characteristic of the reproduction voltage in the GMR element 11 of this operation gestalt. Namely, a vertical bias magnetic field is set up greatly and, as for the GMR element 11 of this operation gestalt, a linear operating range, i.e., the range from which linearity is secured, is set for example, as **39.7 kA/m. For this reason, the GMR element 11 of this operation gestalt is set up so that it may not be saturated, even if the strong reproduction magnetic field from a disk 101 is impressed. In this case, the saturation magnetic field Hs in the magnetic field response characteristic of the GMR element 11 is for example, 39.7 kA/m. a ratio with the product Mrt of the residual magnetization of the CoPt system hard magnetic film (not shown) specifically prepared in the edge of a slider at the product Mst of magnetization and thickness and the object for vertical bias of a CeFe/NiFe free layer of a spin bulb GMR element, and thickness -- Mrt/Mst is preferably set as 4.0 three or more As a reproduction average magnetic field in the GMR element 11, even if the magnetic field from the 39.7kA [/m] disk 101 flows, it is set up so that the reproduction response characteristic of the GMR element 11 may not be saturated.

[0030] Drawing 3 is drawing showing the reproduction wave (output wave) from the GMR element 11 of this operation gestalt. It was checked that the reproduction wave concerned is a wave as which a saturation phenomenon is not regarded so that clearly from comparison with the reproduction wave (see drawing 9) in which the saturation phenomenon mentioned later has occurred. In addition, the vertical axis of drawing 3 is a head output (reproduction output) of a read head which consists of a GMR element 11, and is an arbitrary unit.

[0031] Drawing 4 is as a result of [of a magnetic field distribution of the perpendicularly the GMR element 11 of this operation gestalt receives from a disk 101] a simulation. A vertical axis shows the internal magnetic field (Hy) of the GMR element 11 among drawing, and a horizontal axis is equivalent to the position of the GMR element 11, and shows the distance (y) from disk 101 front face. As a position of the GMR element 11, it is the distance y of the range of 21 to 321nm, for example.

[0032] In short, this simulation shows the distribution (41, 40, 42) of the magnetic field of a perpendicular direction [as opposed to the disclosure magnetic field (Hys, Hy, Hyb) from the crevice between the magnetic shielding 10 of a couple in the GMR element 11], when it gets it blocked and is in the residual magnetization state of "Mr=3.87T", the state which magnetization of the record magnetic layer 3 of a disk 101 magnetized uniformly to ** on the other hand, and. Hys is contribution from magnetization of the front face of the record magnetic layer 3, Hby is contribution from the rear face of the record magnetic layer 3, and the sum Hy of Hys and Hyb is impressed to the GMR element 11.

[0033] Drawing 5 is drawing showing a relation with each of the position 50 of the GMR element 11, the reproduction average magnetic field 51 of the GMR element 11 interior, and the maximum magnetic field strength 52 in the simulation result shown in drawing 4 . The reproduction average magnetic field 51 (Hmu) in the GMR element 11 is 36.1 (kA/m) at the maximum, and drawing 5 shows that the GMR element 11 concerned receives 2 or the 3 times as many strong magnetic field as this of the disclosure magnetic field (magnetic field from a disk) which the GMR element in the conventional magnetic-recording method within a field receives. The magnetic field distribution of the GMR element 11 interior is settled within the range**39.7 (kA/m) from which the linearity of the magnetic field response characteristic of the above-mentioned GMR element 11 is secured. In this case, relational expression "the reproduction average magnetic field Hmu< saturation magnetic field Hs" is materialized. Here, the maximum magnetic field strength (Hopmax) of the alignment response range of the GMR element 11 is 37.3 (kA/m). The relational expression "Hopmax>Hmu" of this maximum magnetic field strength (Hopmax) and a reproduction average magnetic field (Hmu) is materialized. Drawing 6 is drawing showing the average magnetic field response characteristic to the output of the GMR element 11, and shows the relation of the maximum magnetic field strength (Hopmax), the saturation magnetic field Hs, and an artificial antiferromagnetism joint magnetic field (Hex).

[0034] Drawing 8 and drawing 9 are drawings showing the magnetic field response characteristic and its reproduction wave of reproduction voltage of the GMR element which suits the conventional magnetic-recording method within a field, respectively. As compared with the GMR element 11 of this operation gestalt, as shown in drawing 8 , **31.8 kA/m order to a saturation phenomenon becomes [the intensity of the disclosure magnetic field from a disk] remarkable. For this reason, as shown in drawing 9 , the output wave of a GMR element turns into a reproduction wave in which the influence of a saturation phenomenon (90) appeared.

[0035] With the GMR element which suits the magnetic-recording method within a field taken up as an example of comparison with the GMR element 11 of this operation gestalt here, the saturation magnetic field Hs in a magnetic field response characteristic is 15.9 or 23.8 (kA/m) grade. It becomes relational expression "the reproduction average magnetic field Hmu> saturation magnetic field Hs", and is not satisfied [with this condition] of the above-mentioned desirable conditional expression "Hmu<Hs." In the right direction, in 15.9 (kA/m) grade and the negative direction, the maximum magnetic field strength (Hopmax) is 4.0 (kA/m) grade, and is smaller [all] than the value of an average magnetic field (Hmu). The ratio "Mrt/Mst" of the product Mst of the magnetization and thickness of the free layer of a

spin bulb GMR element and the product Mrt of the residual magnetization of a CoCr system hard magnetic film (not shown) and thickness which were prepared in the edge of a slider for vertical bias is smaller than 3, and is about 2.5.
[0036] As mentioned above, in the case of magnetic field strength strong like the average magnetic field (Hmu) of the reproduction magnetic field (disclosure magnetic field) from the record magnetic layer 3 of the disk 101 of perpendicular two-layer structure amounts to 36.1 (kA/m), especially the GMR element 11 of this operation gestalt is also set, and becomes possible [avoiding or suppressing a saturation phenomenon]. Therefore, in the disk drive of the vertical magnetic recording which uses the disk 101 of perpendicular two-layer structure especially, when the GMR element 11 of this operation gestalt is used as a read head, a quality regenerative signal without distortion by the saturation phenomenon can be secured. It becomes possible to realize the disk drive which combined by this vertical magnetic recording effective in a raise in recording density, and the read head element which used the GMR element which suited the vertical magnetic recording concerned.
[0037] (Modification 1) This modification assumes the speculer and the artificial switched connection type spin bulb GMR element as a GMR element 11. The structure of the read head 8 which used the GMR element 11 is the same as that of the case of this operation gestalt fundamentally shown in drawing 1 .
[0038] The GMR element 11 about this modification has the film composition of PtMn/CoFe/Ru/NiFe/CoFe/Cu/CoFe/NiFe/CeFeO/Ta. Moreover, a shield interval (Gs), i.e., shield gap length, is about 100nm. The height (H) of the perpendicular direction of a GMR element is about 300nm. An artificial switched connection magnetic field (Hex) is for example, 158.8 (kA/m) grade.
[0039] Here, as mentioned above, write head 9 has the perpendicular single magnetic pole type record magnetic pole 12 which counters a disk 101. Furthermore, write head 9 has the yoke 13 which was magnetically connected behind the record magnetic pole 12 concerned, and has been arranged behind. It lets this yoke 13 pass, is excited with a record coil (not shown), and write head 9 generates the record magnetic field of a strong perpendicular direction to a disk 101.
[0040] Lead / write head 8 and 9 is mounted on the slider whose head 103 is a head main part. A slider has ABS (air bearing surface) for rising to surface on a disk 101. The protective coat 14 for surface protections is formed in this ABS by the thickness which is 3nm. This protective coat 14 consists of DLC protective coats which formed membranes for example, by the cathodic arc process.
[0041] The pattern for generating the positive pressure by the airstream accompanying rotation of a disk 101 is formed in ABS of the slider concerned. A slider surfaces on a disk 101 with the positive pressure concerned, for example, in the case of rotational frequency 4200rpm of a disk 101, the flying height FH in the inside periphery position (it considers as the radius of 23mm) of a disk 101 is set to about 15nm. As shown in drawing 1 from this relation, the distance dmag with the disk side front face of the front face of the record magnetic layer 3 of a disk 101 to the GMR element 11, i.e., a magnetic spacing, is the sum total (for example, 21nm) of the thickness (for example, 3nm) of the flying height FH (for example, 15nm) and a protective coat 14, and the thickness (for example, 3nm) of the protective coat 7 of a disk 101.
[0042] At this time, the maximum magnetic field strength (Hopmax) which is the maximum of the magnetic field impressed to the GMR element 11 turns into 118.1 (kA/m) grade, as shown to Hy (40) of drawing 5 by simulation calculation. Since the magnetic field Hy from a disk 101 is decreased as it trespasses upon the interior of the GMR element 11, it turns into an average magnetic field (Hmu) in the whole height (H) of the GMR element 11. This average magnetic field (Hmu) serves as for example, 36.1 (kA/m) grade. Furthermore, the artificial antiferromagnetism joint magnetic field (Hex) of the GMR element 11 is set up more greatly than 118.1 (kA/m) of the maximum magnetic field (Hmax) which joins the nearest portion locally from the disk 101 which is 158.8 (kA/m) grade and was magnetized uniformly. Thereby, the artificial switched connection of the GMR element 11 can obtain stable reproduction operation, without being reversed by the strong magnetic field from a perpendicular magnetic disk.
[0043] Here, the artificial antiferromagnetism joint magnetic field of the GMR element 11 is assumed to be Hex, and the residual magnetization of dmag and the record magnetic layer 3 concerned is assumed [shield gap length] to be Mr for the distance from the GMR edge of Gs and a head ABS side to the front face of the record magnetic layer 3. In this case, it is assumed that the surface magnetic charge Mr exists in the stripe of length infinite approximation uniformly on the front face Gs of the record magnetic layer 3 which is visible from the crevice between shields, i.e., width of face. And if the situation of the maximum magnetic field of a disk 101 is presumed when it includes to a circumference truck and changes into a uniform DC magnetization state, relational expression "H=8 Mr*arctan [Gs/(2dmag)]" can express in approximation the magnetic field strength (H) impressed to the portion of the nearest GMR element 11 from the disk 101 concerned. At this time, the artificial antiferromagnetism joint magnetic field (Hex) of a GMR element is set up more greatly than the magnetic field strength (H) concerned (Hex>H). Thereby, the artificial switched connection of the GMR element 11 can obtain stable reproduction operation, without being reversed by the strong magnetic field from a disk 101.
[0044] (Modification 2) Drawing 7 is drawing about the modification 2 of this operation gestalt.

[0045] Drawing 7 is the cross section which saw arrangement with the GMR element 20 and the disk 21 of vertical magnetic recording from the width of recording track. The hard magnetic film 24 which gives the vertical bias magnetic field 23 to a part for the GMR magnetic sensitive part 22 and the both ends to the GMR magnetic sensitive part 22 is formed in the GMR element 20. The hard magnetic film 24 has the function to generate the bias magnetic field which is a direction parallel to a disk side, and acts so that a uniform magnetization state (29) may be generated, in the free layer of the GMR magnetic sensitive part 22.

[0046] A disk 21 has the record magnetic layer 25 of a perpendicular anisotropy, the soft-magnetism layer 26 prepared in the lower part as a backing layer, and the hard magnetic film 27. In order to suppress magnetic-domain-wall generating of the soft-magnetism layer 26, switched connection of this hard magnetic film 27 is carried out by the interface of the soft-magnetism layer 26. Moreover, the magnetization 28 of the hard magnetic film 27 is uniformly magnetized in the direction of the width of recording track.

[0047] The interior of the GMR magnetic sensitive part 22 is made to generate a magnetic field 29 by the magnetization 28 of the hard magnetic film 27 of a disk 21, and magnetization (not shown) of the soft-magnetism layer 26 turned in this direction by switched connection with magnetization 28.

[0048] In order to operate receiving the strong reproduction magnetic field from the record magnetic layer 25 of a disk 21 without saturating the GMR magnetic sensitive part 22, it is effective to make the magnetic field 29 from the hard magnetic film 27 of a disk 21 into the vertical bias magnetic field 23 generated from the hard magnetic film 24 of the GMR element 20 in this direction. When it is set as an opposite direction, it acts in the direction which weakens the effect of a vertical bias magnetic field, and operation of the GMR element 20 becomes very unstable.

[0049] By such composition, when a strong reproduction magnetic field is added to the GMR element 20 from a disk 21, since it becomes possible [the GMR magnetic sensitive part 22] to generate a magnetic field 29 in the vertical bias magnetic field 23 generated from the hard magnetic film 24, and this direction, it operates, without causing a saturation phenomenon. Therefore, in the disk drive of the vertical magnetic recording which uses the disk 21 of perpendicular two-layer structure especially, when the GMR element 20 of this modification is used as a read head, a quality regenerative signal without distortion by the saturation phenomenon can be secured. It becomes possible to realize the disk drive which combined by this vertical magnetic recording effective in a raise in recording density, and the read head element which used the GMR element which suited the vertical magnetic recording concerned.

[0050]

[Effect of the Invention] As explained in full detail above, even when it has the influence of the disclosure magnetic field from the disk record medium of perpendicular two-layer structure, or a reproduction magnetic field according to this invention, the read head element which consists of a GMR element which can perform stable reproduction operation which does not have distortion in a regenerative signal can be realized. Therefore, the reproduction magnetic field from a disk record medium becomes possible [realizing relatively the disk drive of the vertical magnetic recording which applied read head elements, such as a GMR element of high sensitivity, to the drive of strong vertical magnetic recording].

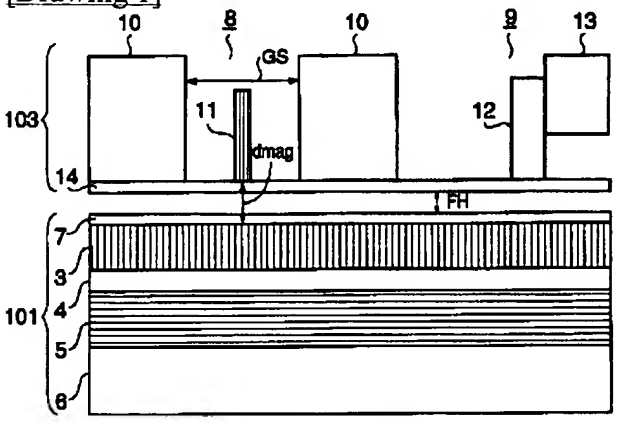
[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

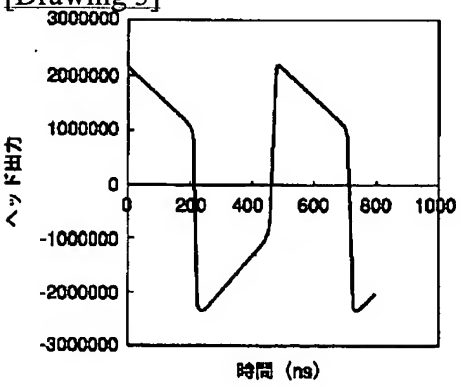
DRAWINGS

[Drawing 1]

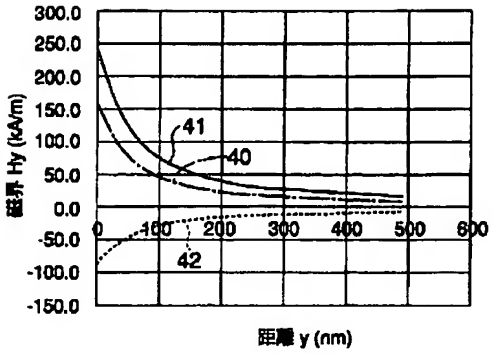


[Drawing 2]

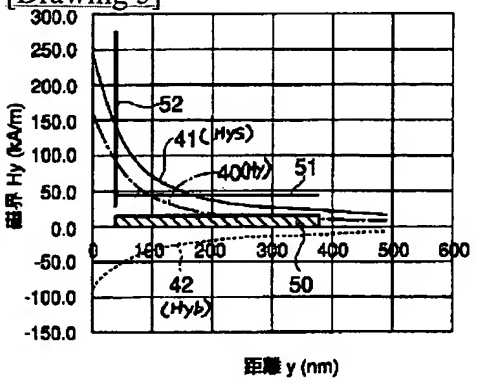
[Drawing 3]



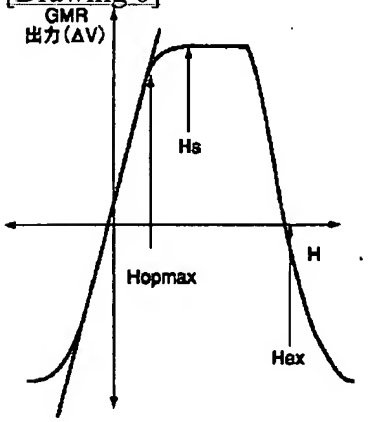
[Drawing 4]



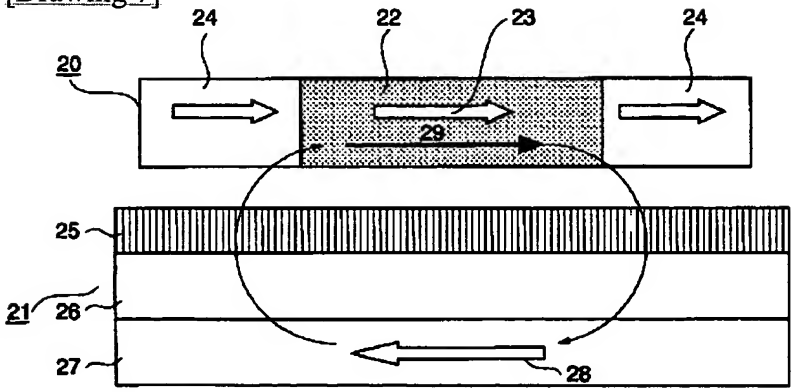
[Drawing 5]



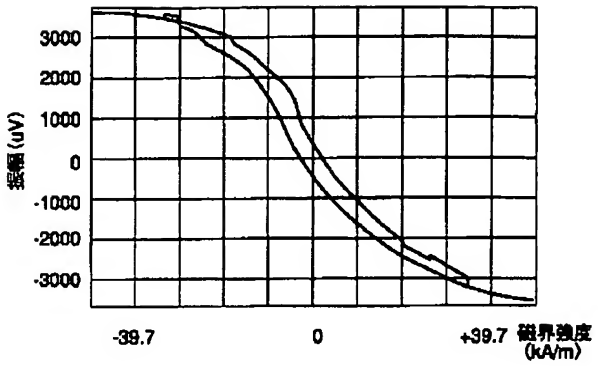
[Drawing 6]



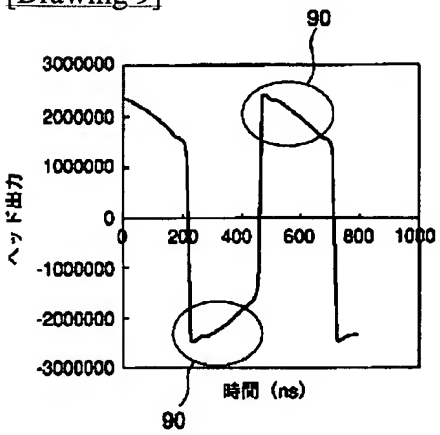
[Drawing 7]



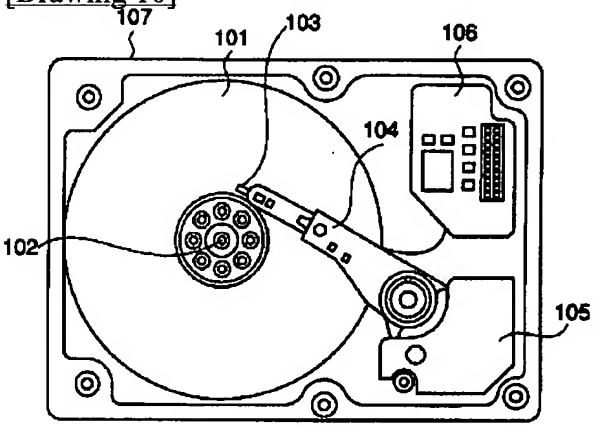
[Drawing 8]



[Drawing 9]



[Drawing 10]



[Translation done.]